Trust Modeling and Evaluation in Nexus

Trust Properties, Metrics and Calculi

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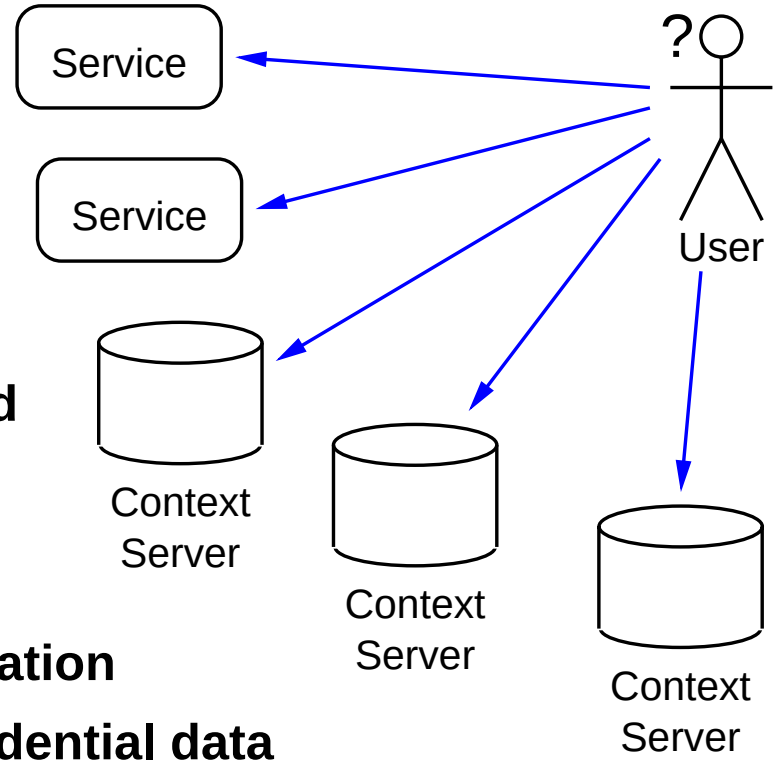
Outline

- **Motivation**
- **Trust Modeling and Evaluation**
  1. Trust Properties
  2. Trust Metrics
  3. Trust Calculi
- **Reputation Systems**
- **Conclusion**

Motivation

Scenario (Nexus)

- **Open platform:**
  anyone can offer
  - services
  - information sources
- **Many (possibly unknown) service and information providers**



“Who can I trust?”

- **Competence, e.g. accuracy of information**
- **Benevolence, e.g. protection of confidential data**

➥ **Need estimation of trustworthiness**

- decision whether or not to use a service
- choice of service provider / information source

Trust Estimation

First-hand knowledge

- **Good / bad experience, technical knowledge, guarantees, ...**

➥ **But: only for few services available!**

Second-hand knowledge

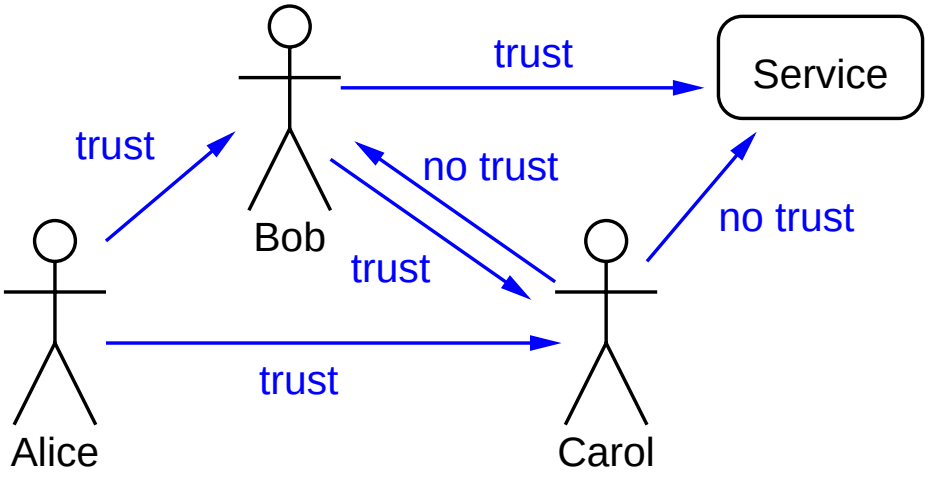
- **Exchange and evaluate trust estimations of other users**

“Who can I trust?”

- **Malicious / incompetent users**
- **Conflicting opinions, uncertainty, ...**

➥ **Need estimation of trustworthiness of trust estimations**

➥ **Complex graphs of trust relations, “Web of Trust”**



Trust Modeling and Evaluation

Assumption

- **All users publish (true or false) trust estimations about other users and services**
- **User A makes correct and independent first-hand estimations about trustworthiness of other users**

Goal

- **Method to combine first-hand trust relations of all users (viewpoint A)**
- **Derive second-hand trust estimations**
  - qualitatively (“Who can I trust?”)
  - quantitatively (“Up to which degree?”)
- **Results should**
  - comply with reasonable intuitive expectations
  - be robust against attacks

➥ **Need a trust model**

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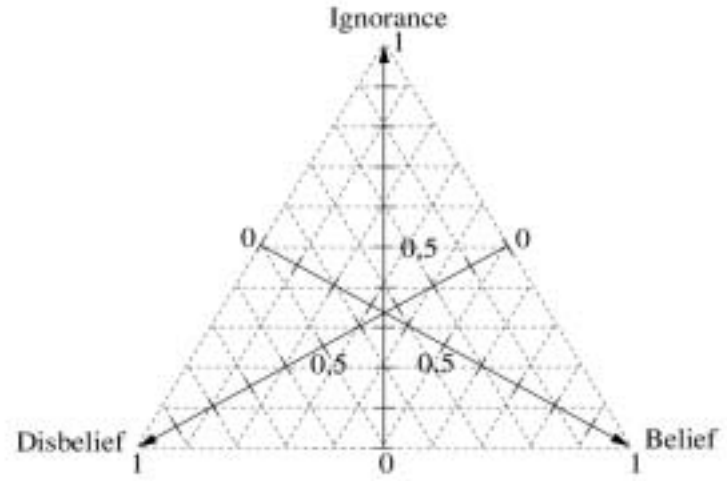
1 Trust Properties

- **Unidirectional relation from truster to trustee (A trusts B)**
- **Trust is not transitive in general**
  - "A trusts B" and "B trusts C" does not imply "A trusts C"
- **Trust is specific (property, context)**
- **Distinguish**
  - direct (functional) trust: "Trustee has this property."
  - indirect (recommender) trust:
    "Trustee can recommend someone who has this property."
    - limit of recommendation hops

2 Trust Metrics (Expressing the Degree of Trust)

- **Range: “distrust” ↔ “no trust” ↔ “trust”**
  - in open systems: negative trust values often not useful
- **Default value:**
  - in open system: choose lowest possible value
- **Uncertainty required?**
- **Granularity:**
  - discrete values, e.g.
    “no trust”, “marginally trust”, “full trust”
  - continuous, e.g.
    trust $\in [0...1]$
  - multi-value:
    trust $\in [-1...1]$,
    confidence $\in [0...1]$
  - upper and lower bound / opinion triangle



From: Audun Jøsang, “Artificial Reasoning with Subjective Logic”

3 Trust Calculus (Combining Trust)

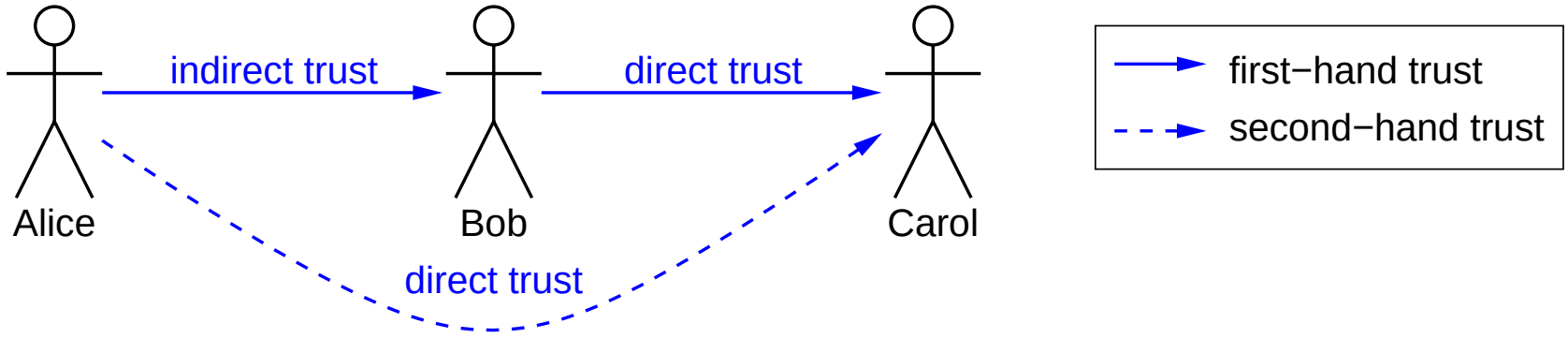
3.1 Combination Rules

- **Set of rules defining**

  which trust relations can be derived

  from set of existing trust relations

- **Example**
  - composition of concatenation of two trust relations
  - trust(A, B, indirect) $\wedge$ trust(B, C, direct) $\Rightarrow$ trust(A, C, direct)



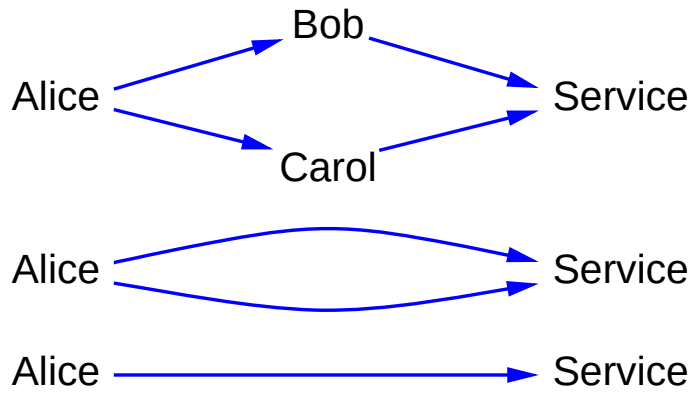
Trust Calculus (2)

3.2 Trust Calculation

3.2.1 Operator-based Trust Calculation

- **Arithmetic operator for each combination rule**
- **Combining trust values of the involved trust relations**
  - e.g. multiplication, min()/max(), average, fuzzy logic operators, ...

➥ **Successive composition of serial and parallel trust relations**



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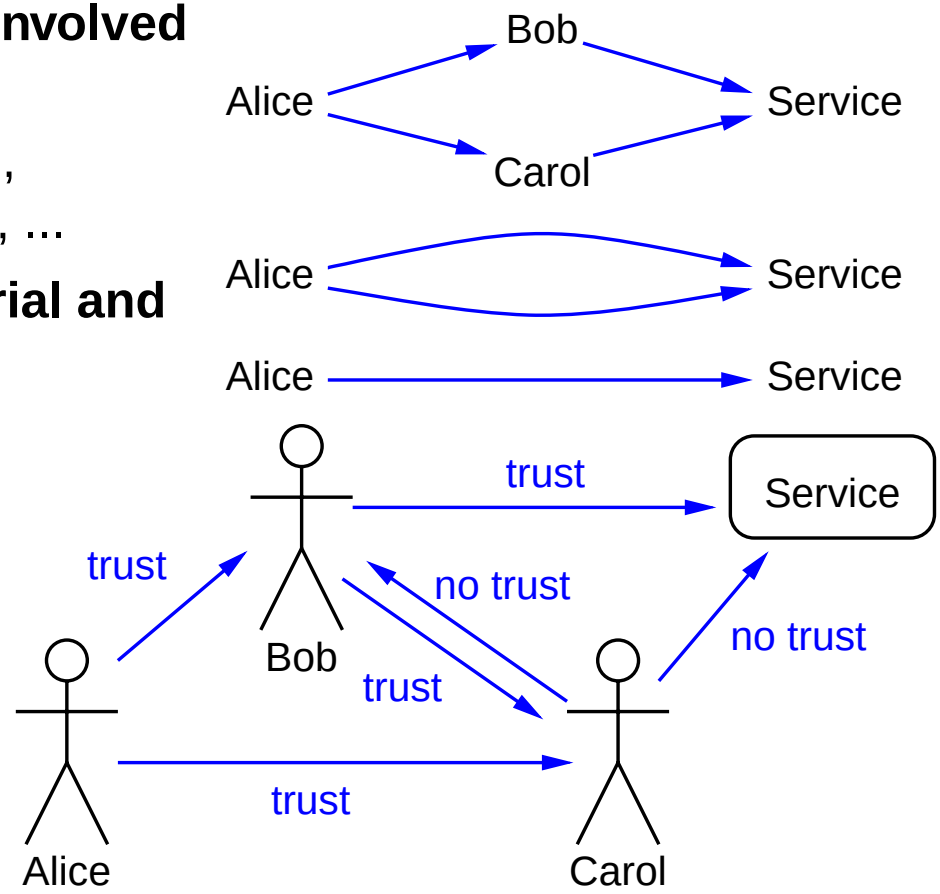
➥ **Successive composition of serial and parallel trust relations**

➥ **Problem:**
only possible, if trust relation graph is a directed series-parallel graph



Trust Calculus (3)

3.2.2 Holistic Trust Calculation

- **Interpret "trust" as "probability that the trustee has the named property"[1]**

➥ **Trust value has a well defined semantic**

➥ **Can use methods of probability theory**

"Possible Worlds" calculation

- **Each trust relation can be valid or invalid**
- **Check for each possible combination ("possible world"), whether the intended trust relation can be derived or not**
- **Calculate the probabilities of all "successful" worlds**

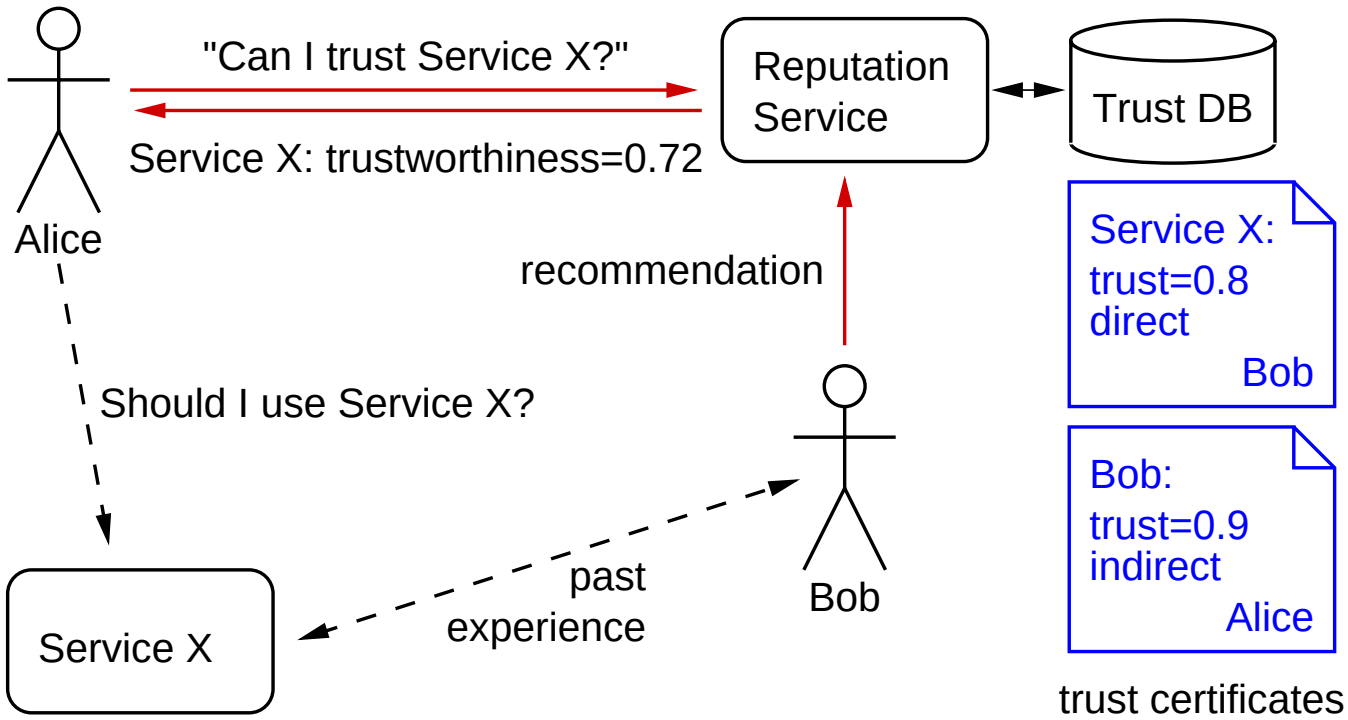
➥ **Resulting trust value is the sum of these probabilities**

  - Drawback: runtime complexity

1. Ueli Maurer, "Modelling a Public-Key Infrastructure"

Application of Trust Models in Reputation Systems

- **Trust relations → trust certificates (digital signature)**
- **Reputation Service**
  - collects trust certificates
  - search trust paths & evaluate resulting trust value



Conclusion and Outlook

Conclusion

- **Trust models can be useful to combine different trust opinions**
- **Reputation system do not aim to create or increase trust, but to calculate a precise estimation**
- **Trust models must carefully distinguish**
  - direct and indirect trust (transitivity)
  - first-hand and second-hand trust estimations
- **Operator-based trust calculation → may cause problems**
- **Interpretation "trust=probability"→ sound basis for trust models**

Outlook

- **Which trust calculus is the "right" one?**
- **Trustworthiness of federated services?**
- **Integration reputation system + PKI**